US009317008B2

(12) **United States Patent**
Handa et al.

(10) **Patent No.: US 9,317,008 B2**
(45) **Date of Patent: Apr. 19, 2016**

(54) **IMAGE FORMING APPARATUS EMPLOYING CLEANERLESS SYSTEM**

(71) Applicant: **Brother Kogyo Kabushiki Kaisha**, Nagoya-shi, Aichi-ken (JP)

(72) Inventors: **Hiroshi Handa**, Inazawa (JP); **Takeshi Bito**, Inazawa (JP); **Hiroki Mori**, Nagoya (JP)

(73) Assignee: **Brother Kogyo Kabushiki Kaisha**, Nagoya-shi, Aichi-ken (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **14/593,076**

(22) Filed: **Jan. 9, 2015**

(65) **Prior Publication Data**

US 2015/0117903 A1 Apr. 30, 2015

Related U.S. Application Data

(63) Continuation-in-part of application No. PCT/JP2012/080845, filed on Nov. 29, 2012.

(30) **Foreign Application Priority Data**

Jul. 9, 2012 (JP) 2012-154154

(51) **Int. Cl.**
G03G 15/24 (2006.01)
G03G 21/18 (2006.01)
G03G 21/00 (2006.01)

(52) **U.S. Cl.**
CPC ***G03G 21/1814*** (2013.01); ***G03G 21/0064*** (2013.01)

(58) **Field of Classification Search**
CPC G03G 15/0898; G03G 21/0064
USPC 399/103, 149, 150, 313
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,864,736	A *	1/1999	Shimada et al.	399/149
6,029,034	A *	2/2000	Itsukushima et al.	399/149
6,088,555	A	7/2000	Mizuno	
6,314,257	B1	11/2001	Ishii et al.	
6,438,331	B2 *	8/2002	Sakaizawa et al.	399/149
6,839,530	B2 *	1/2005	Takahashi et al.	399/149

(Continued)

FOREIGN PATENT DOCUMENTS

JP	H06-148967	A	5/1994
JP	H08-194417	A	7/1996

(Continued)

OTHER PUBLICATIONS

Jan. 22, 2015—(WO) Translation of the Int'l Prelim Report on Patentability—App PCT/JP2012/080845.

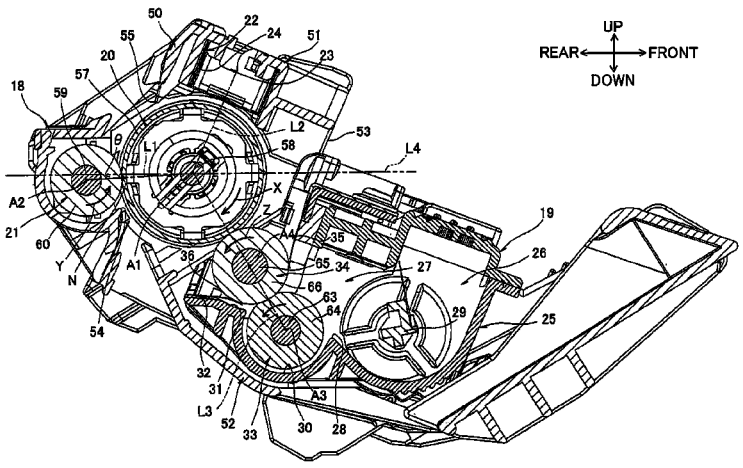
(Continued)

Primary Examiner — William J Royer
(74) *Attorney, Agent, or Firm* — Banner & Witcoff, Ltd.

(57) **ABSTRACT**

An image forming apparatus includes a developing roller and a photosensitive drum configured to rotate about a first axis, and has a peripheral surface. The developing roller is configured to contact the photosensitive drum and is configured to supply developer to the photosensitive drum by rotating about a second axis positioned lower than the first axis in a vertical direction to form a visible image on the peripheral surface. Extraneous matter on the peripheral surface is recovered only by the developing roller.

13 Claims, 3 Drawing Sheets



15

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,113,199	B2	9/2006	Hattori
8,374,523	B2	2/2013	Kato
2004/0100547	A1	5/2004	Hattori
2008/0145093	A1	6/2008	Fukuta et al.
2011/0076049	A1	3/2011	Kato
2011/0158682	A1	6/2011	Takagi et al.

FOREIGN PATENT DOCUMENTS

JP	H10-268734	A	10/1998
JP	2000-315014	A	11/2000
JP	2004-077799	A	3/2004
JP	2005-141019	A	6/2005
JP	2007-304447	A	11/2007
JP	2008-170936	A	7/2008
JP	2010-091981	A	4/2010
JP	2011-075653	A	4/2011
JP	2011-133759	A	7/2011

OTHER PUBLICATIONS

Nov, 24, 2015—(JP) Office Action—App 2012-154154, Eng Tran.
Feb. 9, 2016—(JP) Office Action—App 2012-154154, Eng Tran.

* cited by examiner

FIG. 1

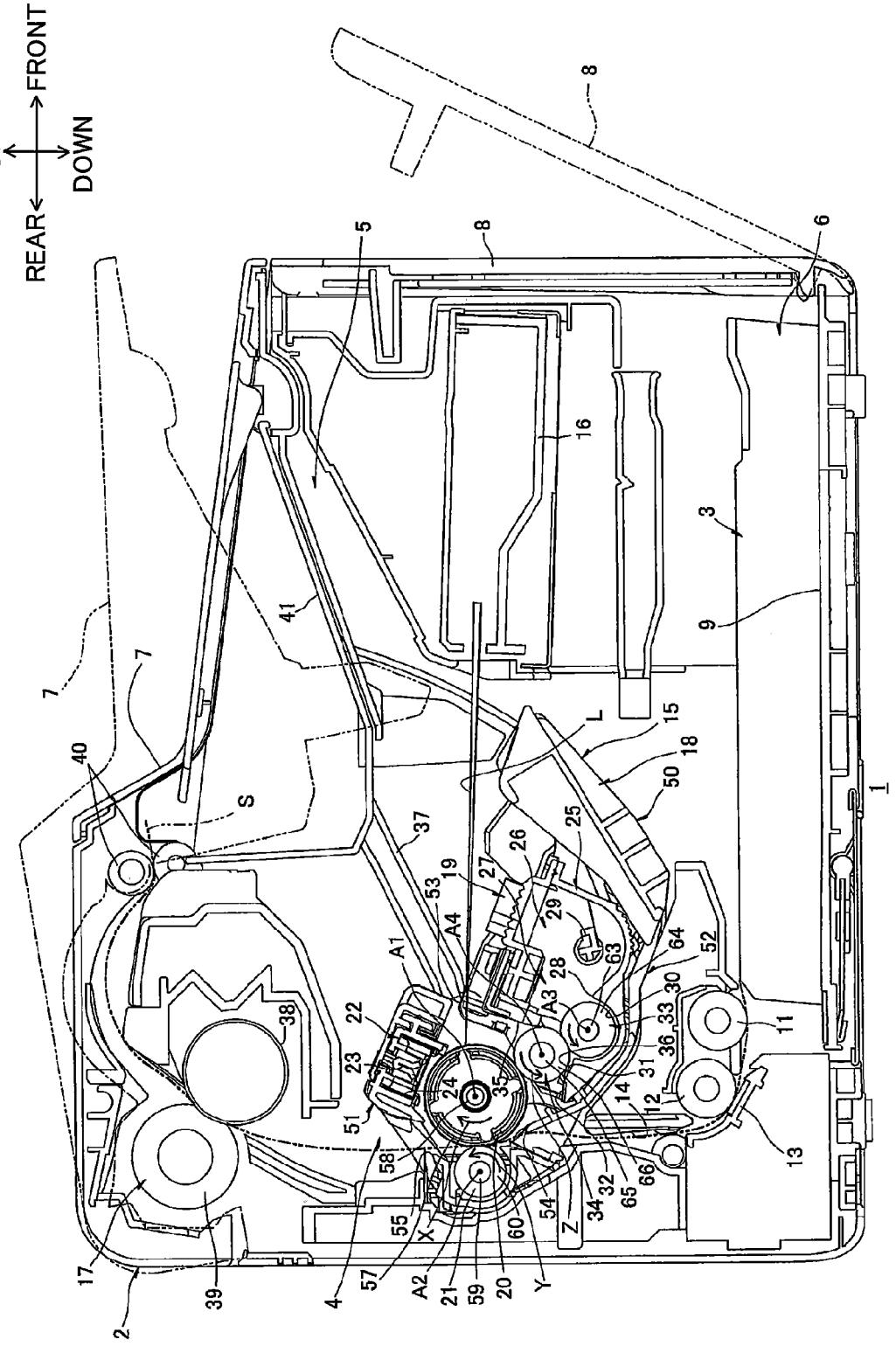

UP
FRONT
REAR
DOWN
1
2
3
4
5
6
7
8
9
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
50
51
52
53
54
55
57
58
59
60
63
64
65
66
A1
A2
A3
A4
L
S
X
Y
Z

FIG. 2

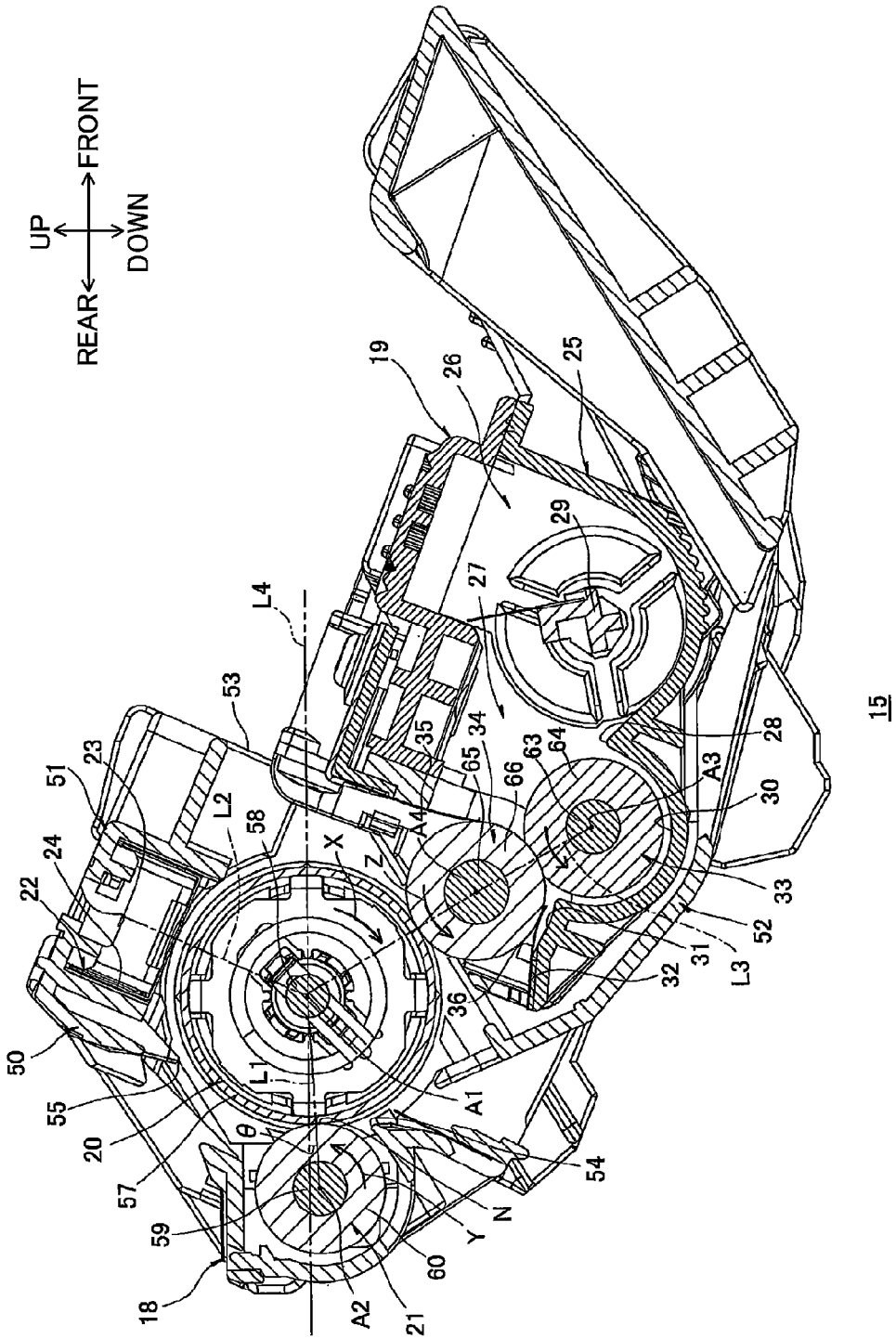

UP
FRONT
REAR
DOWN
15
19
26
25
29
27
L4
53
35
34
63
64
28
A3
30
65
66
A4
51
23
L2
58
X
Z
24
22
33
52
31
L3
32
36
50
L1
A1
55
θ
20
54
57
59
N
Y
60
18
A2
21

FIG. 3

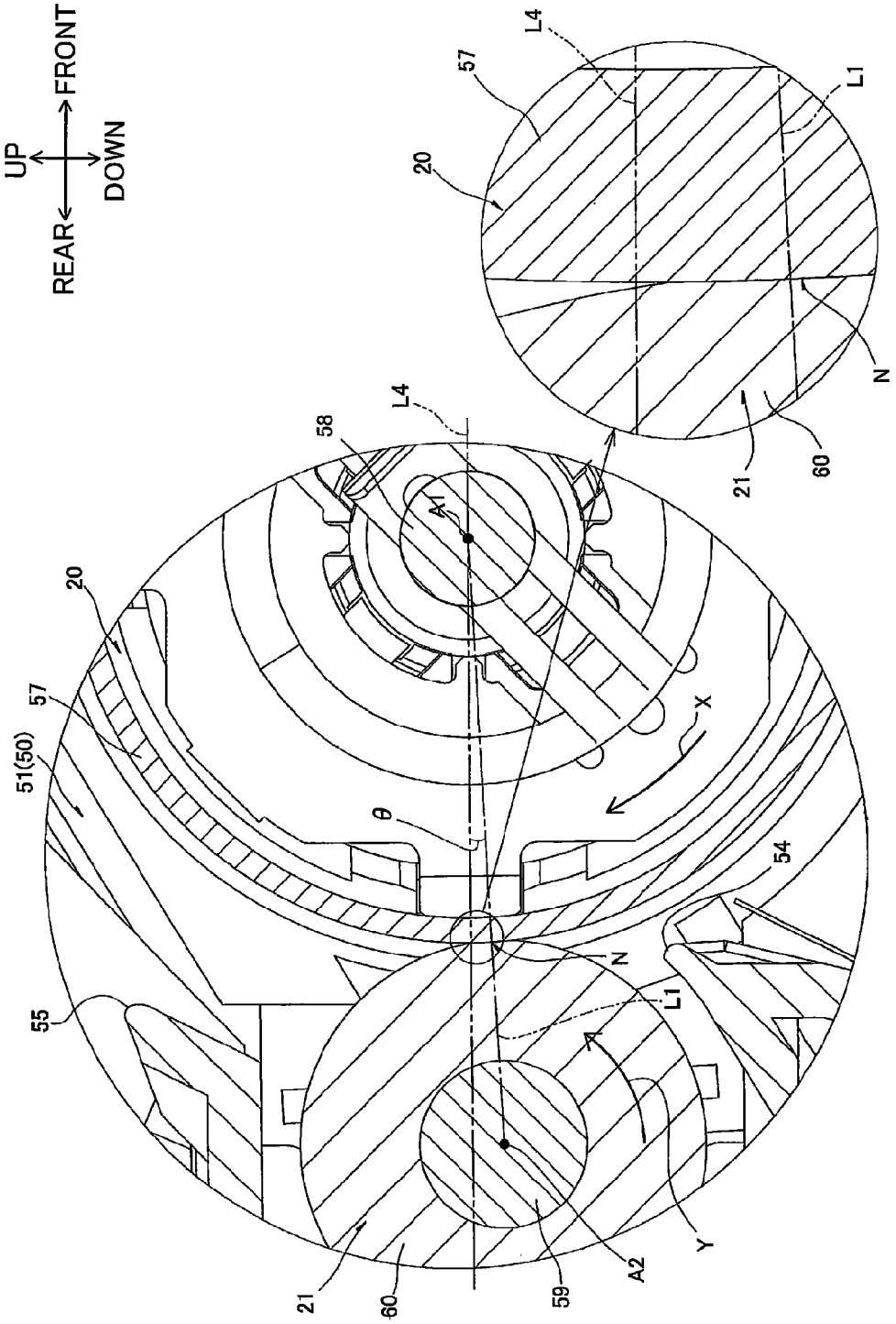


IMAGE FORMING APPARATUS EMPLOYING CLEANERLESS SYSTEM

CROSS REFERENCE TO RELATED APPLICATION

This application claims priority from Japanese Patent Application No. 2012-154154 filed Jul. 9, 2012. This application is also a continuation-in-part of International Application No. PCT/JP2012/080845 filed Nov. 29, 2012 in the Japanese Patent Office as a Receiving Office. The contents of these applications are incorporated herein by reference.

TECHNICAL FIELD

The present invention relates to an image-forming device employing an electrophotographic system.

BACKGROUND

One electrophotographic image-forming device known in the art is a printer, as described in Japanese Patent Application Publication No. H08-194417 (Patent Document 1), that comprises a photosensitive drum on which an electrostatic latent image is formed, a developing roller that confronts and contacts the photosensitive drum and supplies toner to the electrostatic latent image, and a cleaning blade that scrapes off extraneous matter (toner, for example) from the circumferential surface of the photosensitive drum that was deposited on the surface during image formation.

In this printer, the distal end of the cleaning blade contacts the circumferential surface of the photosensitive drum to scrape off extraneous matter deposited on the circumferential surface.

SUMMARY

However, since the distal end of the cleaning blade constantly contacts the circumferential surface of the photosensitive drum in the printer described in the Patent Document 1, the cleaning blade may scratch the surface of the photosensitive drum through numerous image-forming operations.

Therefore, it is an object of the present invention to provide an image-forming device capable of suitably removing and recovering extraneous matter from the circumferential surface of the photosensitive drum while suppressing scratching of the circumferential surface.

In order to attain the above and other objects, the invention provides an image forming apparatus including a developing roller and a photosensitive drum configured to rotate about a first axis and having a peripheral surface. The developing roller may be configured to contact the photosensitive drum and is configured to supply developer to the photosensitive drum by rotating about a second axis positioned lower than the first axis in a vertical direction to form a visible image on the peripheral surface. Extraneous matter on the peripheral surface may be recovered only by the developing roller.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

FIG. **1** is a cross-sectional view of a printer according to an embodiment of the present invention;

FIG. **2** is a cross-sectional view of a process cartridge (mounted in a main casing) shown in FIG. **1** as viewed in a horizontal direction; and

FIG. **3** is an enlarged view showing a main portion of a contacting part between a transfer roller and a developing roller shown in the FIG. **2**.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

1. Printer

FIG. **1** shows a printer **1** serving as an example of an image forming apparatus that is provided with a main casing **2** having a box-like shape.

Within the main casing **2**, the printer **1** is also provided with a sheet-feeding unit **3** for feeding sheets S (one example of a recording medium) of paper, and an image-forming unit **4** for forming images on the sheets S supplied by the sheet-feeding unit **3**.

Directions will be specified based on orientations of these units when resting on a level surface, and specifically will refer to the directions indicated by arrows in the drawings. The right side of FIG. **1** is referred to as front, and the left side as rear; and the back side of the paper surface is referred to as right, and the front side of the paper surface as left. In this manner, each of the directions is indicated. In this case, the left and the right are defined based on the directions when the printer **1** is viewed from the front side. Incidentally, the frontward/rearward direction and the leftward/rightward direction are respectively referred to as the horizontal direction and the vertical direction.

(1) Main Casing

Formed in the main casing **2** are a cartridge access opening **5** for mounting and removing a process cartridge **15** (described later), and a paper-introducing opening **6** through which the sheets S of paper are inserted into the main casing **2**.

The cartridge access opening **5** is formed in an upper end portion of the main casing **2**, penetrating the main casing **2** vertically.

The paper-introducing opening **6** is formed in a bottom portion on a front end portion of the main casing **2** and penetrates the front end portion in a frontward/rearward direction.

The main casing **2** also includes a top cover **7** disposed on the upper end portion thereof, and a sheet-feeding cover **8** disposed on the front end portion thereof. The top cover **7** is provided with a discharge tray **41**.

The top cover **7** is disposed so as to be capable of pivoting (moving) about its rear edge portion between a closed position for covering the cartridge access opening **5**, and an open position for exposing the cartridge access opening **5** (see two-dot chain lines in FIG. **1**).

The sheet-feeding cover **8** is disposed so as to be capable of pivoting (moving) about its bottom edge portion between a first position for covering the paper-introducing opening **6**, and a second position for exposing the paper-introducing opening **6** (see two-dot chain lines in FIG. **1**).

(2) Sheet-Feeding Unit

The sheet-feeding unit **3** includes a sheet-supporting part **9** provided in a lower portion of the main casing **2**.

The sheet-supporting part **9** is in communication with the exterior of the main casing **2** through the paper-introducing opening **6**.

The sheets S of paper are placed in the sheet-feeding unit **3** when the sheet-feeding cover **8** is in its second position. More specifically, the sheets S are inserted through the paper-introducing opening **6** such that rear portions of the sheets S are

stacked in the sheet-supporting part **9** and front portions of the sheets S are stacked on a top surface of the sheet-feeding cover **8**.

The sheet-feeding unit **3** further includes a pickup roller **11** disposed above a rear edge portion of the sheet-supporting part **9**, a feeding roller **12** disposed rearward of the pickup roller **11**, a feeding pad **13** arranged to confront the lower rear side of the feeding roller **12**, and a feeding path **14** extending continuously upward from a rear edge of the feeding pad **13**.

(3) Image-Forming Unit

The image-forming unit **4** includes the process cartridge **15**, a scanning unit **16** as an example of an exposing device, and a fixing unit **17**.

(3-1-1) Process Cartridge

The process cartridge **15** is detachably mounted in the main casing **2**. When mounted in the main casing **2**, the process cartridge **15** is arranged above a rear portion of the sheet-feeding unit **3**.

The process cartridge **15** includes a drum cartridge **18** and a developing cartridge **19** that is detachably mounted in the drum cartridge **18**.

(3-1-1) Drum Cartridge

As shown in FIG. **2**, the drum cartridge **18** is provided with a drum frame **50**.

The rear portion of the drum frame **50** is formed as a drum-accommodating section **51**, and the front portion of the drum frame **50** is formed as a cartridge-mounting section **52**.

The drum-accommodating section **51** is formed in a box-like shape that is elongated in the leftward/rightward direction and open on the front side. The open front side of the drum-accommodating section **51** is defined as a drum opening **53** and serves as an example of an exposure opening (see FIG. **1**).

The drum-accommodating section **51** accommodates a photosensitive drum **20**, a transfer roller **21**, and a scorotron charger **22** serving as an example of a charger in the invention.

The photosensitive drum **20** includes a drum body **57** and a drum shaft **58**.

The drum body **57** includes a metal tube formed in a general cylindrical shape whose axis is aligned in the leftward/rightward direction, and a resinous photosensitive layer covering the surface of the metal tube.

The drum shaft **58** is formed of metal and has a general columnar shape, with its axis oriented in the leftward/rightward direction. The leftward/rightward dimension of the drum shaft **58** is greater than the leftward/rightward dimension of the drum body **57**. The drum shaft **58** is rotatably inserted inside the drum body **57** such that its central axis is aligned with the central axis of the drum body **57**.

The photosensitive drum **20** is provided in the approximate center region of the drum-accommodating section **51** such that the circumferential surface of the drum body **57** positioned on the front side is exposed through the drum opening **53**.

The left and right ends of the drum shaft **58** are supported by the drum-accommodating section **51**, and therefore the photosensitive drum **20** is capable of rotating about the central axis A**1** of the drum body **57** (an example of a first axis).

In an image-forming operation (described later), a drive force is transmitted to the drum body **57** from a motor or other drive source (not shown) provided in the main casing **2** for driving the drum body **57** to rotate in a rotating direction X (clockwise in a left side view) indicated by the arrow in the drawings.

The transfer roller **21** includes a metal transfer-roller shaft **59** whose axis is oriented in the leftward/rightward direction, and a roller body **60** that covers the transfer-roller shaft **59** while leaving the left and right ends of the transfer-roller shaft **59** exposed. The roller body **60** is formed of an electrically conductive rubber or an electrically conductive sponge.

The transfer roller **21** is provided in the rear portion of the drum-accommodating section **51** such that the roller body **60** contacts and presses the rear side of the drum body **57**.

As shown in FIG. **3**, the transfer roller **21** is disposed on the rearward of the photosensitive drum **20** such that its central axis A**2** (described later) is positioned slightly lower than the central axis A**1** of the photosensitive drum **20**. However, as illustrated in FIG. **2**, the bottom surface of the transfer roller **21** is positioned higher than the bottom surface of the photosensitive drum **20**.

Accordingly, the weight of the transfer roller **21** has no influence on the amount of pressure with which the transfer roller **21** presses against the photosensitive drum **20** (transfer pressure).

That is, as shown in FIG. **3**, a virtual line segment L**1** connecting the central axis A**2** (described later) of the transfer roller **21** to the central axis A**1** of the photosensitive drum **20** forms an acute angle θ with a virtual line L**4** extending horizontally in the frontward/rearward direction and passing through the central axis A**1** of the photosensitive drum **20**. The acute angle θ can be set greater or equal to 0 (zero) degrees and smaller or equal to 10 degrees, for example, and preferably approximately 3 degrees.

As shown in FIG. **1**, this arrangement allows sheets S to be supplied to a contacting part N (see FIG. **3**) between the roller body **60** of the transfer roller **21** and the drum body **57** of the photosensitive drum **20** and to convey the sheets S slightly forward as the sheets S that passed the contacting part N moves in an upward direction toward the fixing unit **17** (to a position between a heating roller **38** and a pressure roller **39** described later). The contacting part N is an example of a contact portion in the invention.

As shown in FIG. **3**, the entire contacting part N between the roller body **60** and drum body **57** is positioned below the virtual line L**4**, i.e., lower than the central axis A**1** of the photosensitive drum **20**.

As shown in FIG. **2**, the transfer roller **21** is rotatable about its central axis A**2** (an example of a third axis), with the left and right ends of the transfer-roller shaft **59** supported in the drum-accommodating section **51**.

In an image-forming operation (described later), friction between the roller body **60** and drum body **57** when the photosensitive drum **20** is driven to rotate causes the transfer roller **21** to follow this rotation in a rotating direction Y indicated by the arrow in FIG. **2** and FIG. **3**. (counterclockwise in a left side view). When an image is being formed (described later), a power supply (not shown) provided in the main casing **2** applies a transfer bias (−2000 V (volts), for example) to the transfer-roller shaft **59** of the transfer roller **21**.

The scorotron charger **22** includes a charging wire **23** (see FIG. **1**), and a grid **24**.

The charging wire **23** is arranged in a taut state to extend in the leftward/rightward direction and is disposed so as to confront but remain separated from the upper front side of the photosensitive drum **20**.

The grid **24** is formed to have a general U-shape in a side view and is provided with the opening of the U-shape facing diagonally upward and forward so as to surround the lower and the rear portions of the charging wire **23**.

The scorotron charger **22** is provided in the top portion of the drum-accommodating section **51** on the position upward and frontward of the photosensitive drum **20** such that the bottom portion of the grid **24** confronts but is separated from

the circumferential surface of the drum body **57**. Thus, the scorotron charger **22** is positioned higher than the central axis A**1** and confronts the photosensitive drum **20** with a gap formed therebetween.

More specifically, the scorotron charger **22** is disposed away from the transfer roller **21** along the circumferential direction of the photosensitive drum **20** (the drum body **57**). The scorotron charger **22** is disposed such that the virtual line segment L**1** connecting the central axis A**1** of the photosensitive drum **20** to the central axis A**2** of the transfer roller **21** forms an angle of approximately 120 degrees with a virtual line segment L**2** connecting the central axis A**1** of the photosensitive drum **20** to the charging wire **23**.

A paper feed opening **54** and a paper discharge opening **55** are also formed in the drum-accommodating section **51**. Sheets S are fed through the paper feed opening **54** to the contacting part N between the roller body **60** and the drum body **57** and are discharged through the paper discharge opening **55** after passing through the contacting part N.

The paper feed opening **54** is formed in the bottom of the drum-accommodating section **51** at a position downward and forward of the contacting part N and vertically penetrates the drum-accommodating section **51** in the generally frontward/rearward center region thereof.

The paper discharge opening **55** is formed in the upper portion of the drum-accommodating section **51** at a position upward and forward of the contacting part N and vertically penetrates the drum-accommodating section **51** in its rear portion, and specifically rearward of the scorotron charger **22**. Hence, the paper discharge opening **55** is formed between the scorotron charger **22** and transfer roller **21** in the circumferential direction of the drum body **57**.

The cartridge-mounting section **52** has a box-like shape that forms open ends positioned rearward and upward thereof to allow mounting and removal of the developing cartridge **19**. The cartridge-mounting section **52** is in communication with the drum-accommodating section **51** via the drum opening **53**.

The rear end portion of the cartridge-mounting section **52** is coupled to the front end portion of the drum-accommodating section **51**, and the cartridge-mounting section **52** is arranged so as to slope downward toward the front.

(3-1-2) Developing Cartridge

The developing cartridge **19** is detachably mounted on the cartridge-mounting section **52** of the drum cartridge **18**, and is positioned downward and frontward of the photosensitive drum **20**.

The developing cartridge **19** also includes a developing-cartridge frame **25**.

The developing-cartridge frame **25** is formed in a box-like shape that is elongated in the leftward/rightward direction. A toner-accommodating chamber **26** and a development chamber **27** are formed in the developing-cartridge frame **25**. The toner-accommodating chamber **26** and the development chamber **27** are aligned in the frontward/rearward direction, with a communication opening **28** allowing communication therebetween. The toner-accommodating chamber **26** and the development chamber **27** have substantially the same capacity.

The toner-accommodating chamber **26** accommodates toner (an example of a developer). An agitator **29** is provided in the generally frontward/rearward and vertical center region of the toner-accommodating chamber **26**. In other words, the agitator **29** is positioned lower than the photosensitive drum **20**.

The top surface on the bottom wall of the development chamber **27** forms a supply-roller groove **30**, a developing-roller opposing surface **31**, and a lower-film adhering surface **32**.

The supply-roller groove **30** is formed in a general semi-circular shape conforming to a circumferential surface of a supply roller **33** (described later), with the convex shape of the supply-roller groove **30** facing obliquely downward and rearward.

The developing-roller opposing surface **31** is formed in a generally arc shape that conforms to the circumferential surface of a developing roller **34** (described later). The developing-roller opposing surface **31** extends continuously in a direction upward and rearward from the rear portion of the supply-roller groove **30**.

The lower-film adhering surface **32** is formed continuously with the rear end portion of the developing-roller opposing surface **31** and extends in a direction sloping slightly upward toward the rear. Thus, the lower-film adhering surface **32** is arranged higher than the developing-roller opposing surface **31**.

The lower-film adhering surface **32** is also arranged so as to vertically confront the bottom portion of the drum body **57** constituting the photosensitive drum **20** with a gap formed therebetween. The lower-film adhering surface **32** is arranged to overlap the central axis A**1** of the photosensitive drum **20** when viewed in the vertical direction.

The supply roller **33**, the developing roller **34**, a thickness-regulating blade **35**, and a lower film **36** as an example of a film member are provided in the development chamber **27**.

The supply roller **33** is provided with a metal supply-roller shaft **63** oriented in the leftward/rightward direction, and an electrically conductive sponge roller **64** that covers the supply-roller shaft **63** while leaving the left and right ends of the supply-roller shaft **63** exposed.

The supply roller **33** is disposed on the rear side of the toner-accommodating chamber **26** with its bottom portion arranged in the supply-roller groove **30**. The supply roller **33** is positioned at the same approximate height as the toner-accommodating chamber **26**.

The supply roller **33** is arranged in the front portion of the development chamber **27** with the left and right ends of the supply-roller shaft **63** supported in the developing-cartridge frame **25** and is rotatable about its central axis A**3**.

During image formation (described later), a drive source (not shown) such as a motor provided in the main casing **2** transmits a drive force to the supply roller **33**. The supply roller **33** is driven to rotate in the rotating direction indicated by the arrow in FIG. **2** (counterclockwise in a left side view) such that the portion of the supply roller **33** confronting and contacting the developing roller **34** (described later) moves in the opposite direction as the developing roller **34**. Also during image formation, a power supply (not shown) provided in the main casing **2** applies a supply bias (+400 V (volts), for example) to the supply-roller shaft **63** of the supply roller **33**.

The developing roller **34** is provided with a metal developing-roller shaft **65** oriented in the leftward/rightward direction and an electrically conductive rubber roller **66**. The rubber roller **66** covers the developing-roller shaft **65** while leaving the left and right ends of the developing-roller shaft **65** exposed.

The developing roller **34** is arranged such that the lower circumferential surface of the rubber roller **66** opposes the developing-roller opposing surface **31** yet remains separated therefrom.

The developing roller **34** is also disposed so as to contact the upper rear side of the supply roller **33** and so that its top

and rear side surfaces are exposed outside of the development chamber **27** and contact the lower front surface of the drum body **57** comprising the photosensitive drum **20**. In other words, the developing roller **34** is arranged on the upper rear side of the supply roller **33** and the lower front side of the photosensitive drum **20** so as to be sandwiched between the two. That is, the supply roller **33** is disposed on the opposite side of the developing roller **34** from the photosensitive drum **20**.

Further, the developing roller **34** is arranged such that its central axis A**4** (described later) is lower than the central axis A**1** of the photosensitive drum **20**. The central axis A**1** of the photosensitive drum **20**, central axis A**4** of the developing roller **34**, and central axis A**3** of the supply roller **33** are generally all aligned on the same virtual line L**3** that follows a radial direction of the drum body **57**.

The developing roller **34** is also disposed in a position separated from the scorotron charger **22** along the circumferential direction of the drum body **57**. More specifically, the developing roller **34** is arranged such that the virtual line segment L**2** connecting the central axis A**1** of the photosensitive drum **20** to the charging wire **23** forms an angle of approximately 120 degrees with the virtual line L**3** connecting the central axis A**1** of the photosensitive drum **20** to the central axis A**4** of the developing roller **34**. Hence, the developing roller **34**, scorotron charger **22**, and transfer roller **21** are arranged at substantially equal intervals along the circumferential direction of the drum body **57**. It is noted that only the rubber roller **66** of the developing roller **34** and the roller body **60** of the transfer roller **21** are in contact with the drum body **57**.

The developing roller **34** is arranged in the rear portion of the development chamber **27**, with the left and right ends of the developing-roller shaft **65** supported in the developing-cartridge frame **25** and is rotatable about the central axis A**4** (an example of a second axis).

During an image-forming operation (described later), a drive source (not shown) such as a motor provided in the main casing **2** transmits a drive force to the developing roller **34**. From this drive force, the developing roller **34** is driven to rotate in a rotating direction Z indicated by an arrow in FIG. **2** (counterclockwise in a left side view).

Note that the circumferential velocity of the developing roller **34** is 1.35 to 1.65 times larger than the circumferential velocity of the photosensitive drum **20** (the drum body **57**), for example, and preferably 1.5 times larger than the circumferential velocity of the photosensitive drum **20**.

During image formation (described later), a power supply (not shown) provided in the main casing **2** applies a developing bias (+300 V (volts), for example) to the developing-roller shaft **65** of the developing roller **34**.

The upper end portion of the thickness-regulating blade **35** is fixed to the rear end portion of the top wall defining the development chamber **27**. The bottom end portion of the thickness-regulating blade **35** contacts the circumferential surface of the rubber roller **66** from the front side thereof.

The lower portion of the lower film **36** is fixed to the lower-film adhering surface **32**. The front end portion of the lower film **36** contacts the circumferential surface of the rubber roller **66** upward of the developing-roller opposing surface **31**. Consequently, the rear edge of the lower film **36** is higher than the front edge of the lower film **36**.

The lower film **36** is disposed below the photosensitive drum **20** such that its rear portion overlaps the central axis A**1** of the photosensitive drum **20** in a vertical projection.

(3-2) Scanning Unit

As shown in FIG. **1**, the scanning unit **16** is arranged frontward of the process cartridge **15** in a position opposing but separated from the photosensitive drum **20** in the frontward/rearward direction.

The scanning unit **16** irradiates a laser beam L (an example of a laser light) based on image data, thereby exposing the circumferential surface of the photosensitive drum **20**.

More specifically, the scanning unit **16** irradiates the laser beam L rearward to expose the circumferential surface of the photosensitive drum **20** on the front side thereof. In other words, the exposure point at which the photosensitive drum **20** is exposed (the circumferential surface on the front side of the photosensitive drum **20**) is configured to be on the opposite side of the central axis A**1** of the photosensitive drum **20** from the contacting part N in which the photosensitive drum **20** and transfer roller **21** contact each other.

At this time, the developing cartridge **19** is arranged beneath the path of the irradiated laser beam L, while the scorotron charger **22** is arranged above the irradiated path of the laser beam L.

Guide parts **37** are provided on inner surfaces of the main casing **2** opposing the space between the scanning unit **16** and photosensitive drum **20** for guiding mounting and removal of the process cartridge **15**. When removing the process cartridge **15** from the main casing **2**, the guide parts **37** guide the process cartridge **15** so that the developing cartridge **19** mounted in the drum cartridge **18** moves upward, passing through the irradiation path of the laser beam L.

At this time, the various rollers provided in the process cartridge **15** (the transfer roller **21**, supply roller **33**, and developing roller **34**) also pass upward through the irradiation path of the laser beam L.

(3-3) Fixing Unit

The fixing unit **17** is disposed above the rear portion of the drum cartridge **18**. More specifically, the fixing unit **17** includes a heating roller **38** disposed above the scorotron charger **22**, and a pressure roller **39** that contacts the heating roller **38** on an upper rear side thereof with pressure.

Hence, the heating roller **38** is disposed near an upper edge (open side edge) of the grid **24** in the scorotron charger **22**.

2. Image-Forming Operation

(1) Developing Operation

As shown in FIG. **2**, the agitator **29** rotates to supply toner from the toner-accommodating chamber **26** of the developing cartridge **19** to the sponge roller **64** of the supply roller **33** through the communication opening **28**. The supply roller **33** in turn supplies the toner onto the rubber roller **66** of the developing roller **34**, at which time the toner is positively tribocharged between the sponge roller **64** and rubber roller **66**.

The thickness-regulating blade **35** regulates the thickness of toner that is positively charged as the developing roller **66** rotates so that a thin layer of toner of uniform thickness is carried on the peripheral surface of the developing roller **34**.

In the meantime, the scorotron charger **22** uniformly charges to e.g. +630 volts on the peripheral surface of the drum body **57** constituting the photosensitive drum **20**. The peripheral surface of the drum body **57** is subsequently exposed to a laser beam L emitted from the scanning unit **16**.

Here, as illustrated in FIG. **1**, the laser beam L emitted from the scanning unit **16** passes over the developing cartridge **19**, through the drum opening **53**, and between the scorotron charger **22** and developing roller **34** with respect to the circumferential direction of the drum body **57** before impinging on the circumferential surface of the drum body **57**.

Through this operation, the scanning unit **16** forms an electrostatic latent image on the circumferential surface of the drum body **57** based on image data.

Here, areas on the circumferential surface of the drum body **57** at which the electrostatic latent image was formed (i.e., the exposed areas) have a potential of +100 V, for example.

As the developing roller **34** and photosensitive drum **20** rotate in the directions indicated in FIG. **2**, the electrostatic latent image formed on the circumferential surface of the drum body **57** moves into confrontation with the rubber roller **66**.

At this time, a prescribed amount of toner carried on the rubber roller **66** is supplied to the latent image formed on the circumferential surface of the drum body **57** due to the developing bias. That is, the amount of toner supplied to the electrostatic latent image is controlled by a developing bias applied to the developing roller **34**.

As a result, a toner image (visible image) is formed on the circumferential surface of the drum body **57** constituting the photosensitive drum **20**.

(2) Sheet-Feeding and Image-Transferring Operations

As shown in FIG. **1**, the rotating pickup roller **11** supplies the sheets S stacked on the sheet-supporting part **9** between the feeding roller **12** and feeding pad **13**, and the rotating feeding roller **12** separates the sheets S, conveys each separated sheet S onto the feeding path **14**, and supplies the sheets S one at a time to the contacting part N between drum body **57** and the roller body **60** at a prescribed timing.

Each sheet S is conveyed from beneath the contacting part N (between the drum body **57** and roller body **60**) to above the same by the rotating drum body **57**, at which time the toner image (visible image) carried on the circumferential surface of the drum body **57** is transferred onto the sheet S by a transfer bias applied to the transfer roller **21** (image-transferring operation).

(3) Fixing and Discharging Operations

After the toner image is transferred onto a sheet S, the sheet S passes through the paper discharge opening **55** and is conveyed to a position between the heating roller **38** and pressure roller **39**.

The heating roller **38** and pressure roller **39** apply heat and pressure to the sheet S as the sheet S passes therebetween to thermally fix the toner image to the sheet S (fixing operation).

The sheet S is subsequently conveyed toward discharge rollers **40**. The discharge rollers **40** discharge the sheet S onto the discharge tray **41** formed on the main casing **2** (Discharging operation).

In this way, the sheet S is supplied from the sheet-supporting part **9** and conveyed along a conveying path that has a general C-shape in a side view, passing first between the photosensitive drum **20** and transfer roller **21** (contacting part N) and next between the heating roller **38** and pressure roller **39**, and subsequently being discharged onto the discharge tray **41**.

3. Operation for Removing and Recovering Extraneous Matter Deposited on the Photosensitive Drum (Cleaning Operation)

During an image-forming operation on the printer **1**, extraneous matter may become deposited on the circumferential surface of the drum body **57** constituting the photosensitive drum **20**.

Examples of this extraneous matter include toner that remains on the circumferential surface of the drum body **57** following a transfer operation (hereinafter referred to as "residual toner") and paper dust or the like (foreign matter) deposited on the circumferential surface of the drum body **57** during a transfer operation as the sheet S passes through the contacting part N.

In the preferred embodiment, the developing roller **34** removes and recovers such extraneous matter (residual toner and paper dust, for example) during the image-forming operation. That is, the developing roller **34** supplies toner to the electrostatic latent image formed on the circumferential surface of the drum body **57** and removes and recovers extraneous matter deposited on the circumferential surface of the drum body **57** during the image-forming operation.

When the extraneous matter is residual toner, the residual toner is brought opposite the scorotron charger **22** by the rotating photosensitive drum **20** and is charged uniformly with a positive polarity. At this time, the residual toner has the generally same potential as that on the circumferential surface of the drum body **57**.

When this residual toner charged to the same approximate potential as the circumferential surface of the drum body **57** is brought facing the rubber roller **66**, the potential difference between the photosensitive drum **20** and the developing roller **34** causes the residual toner to migrate from the photosensitive drum **20** to the developing roller **34** and to be electrostatically retained on the circumferential surface of the rubber roller **66**. As described above, the developing roller **34** electrically supplies a prescribed amount of toner to the latent image formed on the circumferential surface of the drum body **57** at this time.

Thereafter, the residual toner retained on the circumferential surface of the rubber roller **66** is either moved and collected (recovered) in the developing-cartridge frame **25** or resupplied to an electrostatic latent image on the circumferential surface of the drum body **57** as the developing roller **34** rotates.

On the other hand, if the extraneous matter is paper dust or another foreign matter, the paper dust or other foreign matter tends to acquire a more negative charge relative to residual toner in the triboelectric series and consequently is not charged with a positive polarity even after brought facing the scorotron charger **22**.

However, when the rotation of the photosensitive drum **20** brings such foreign matter into confronting the rubber roller **66** of the developing roller **34**, friction from the rubber roller **66** and the force of gravity causes the extraneous matter to be removed from the circumferential surface of the drum body **57** and to be retained on the circumferential surface of the rubber roller **66**.

At this time, a portion of the foreign matter removed from the circumferential surface of the drum body **57** falls due to the force of gravity and is accumulated on the top surface of the lower film **36**.

The foreign matter retained on the circumferential surface of the rubber roller **66** is then moved within the developing-cartridge frame **25** by the rotation of the developing roller **34** until the matter falls by the force of gravity and is recovered (stored) in the developing-cartridge frame **25**.

The foreign matter that accumulates on the top surface of the lower film **36** moves forward due to gravity along the sloped top surface of the lower film **36** until arriving at the circumferential surface of the rubber roller **66**. As the developing roller **34** continues to rotate, the foreign matter passes through the area of contact between the lower film **36** and rubber roller **66** and is moved back inside the developing-cartridge frame **25** (is recovered).

4. Operational Advantages

(1) As shown in FIG. **2**, the printer **1** is configured such that the central axis A**4** of the developing roller **34** is positioned

below (vertically lower than) the central axis A1 of the photosensitive drum **20**. Accordingly, extraneous matter (residual toner, paper dust, and other foreign matter) deposited on the circumferential surface of the drum body **57** constituting the photosensitive drum **20** is reliably recovered on the rubber roller **66** of the developing roller **34** using gravity.

The above configuration offers a cleanerless system in which the developing roller supplies developer to the electrostatic latent image on the photosensitive drum and removes extraneous matter from the circumferential surface of the photosensitive drum while not using a cleaning device (a cleaning blade, for example) for removing the extraneous matter (including developer and foreign matter such as paper dust) that has been deposited on the circumferential surface of the photosensitive drum.

Therefore, the printer **1** can employ a cleanerless system that reliably reduces the amount of extraneous matter left on the circumferential surface of the drum body **57**, thereby suppressing the occurrence of image-forming problems caused by such extraneous matter.

Hence, this configuration minimizes scratching in the circumferential surface of the drum body **57** and reliably recovers extraneous matter deposited on the same surface while enabling the printer **1** to be simplified, made more compact, and reduced in cost.

(2) As shown in FIG. **3**, the transfer roller **21** is arranged with its central axis A2 positioned below (vertically lower than) the central axis A1 of the photosensitive drum **20**.

Accordingly, when a sheet S passes through the contacting part N between the drum body **57** of the photosensitive drum **20** and the roller body **60** of the transfer roller **21**, gravity acts on foreign matter (paper dust, for example) deposited on the surface of the sheet S facing the photosensitive drum **20** in a direction toward the sheet S.

Thus, the foreign matter is suppressed from migrating from the sheet S onto the circumferential surface of the drum body **57**.

Hence, this configuration suppresses the amount of foreign matter on the sheet S that becomes deposited on the circumferential surface of the drum body **57**, thereby reducing the amount of extraneous matter deposited on the circumferential surface of the drum body **57**.

(3) As shown in FIG. **3**, the transfer roller **21** is arranged such that the entire contacting part N is positioned below (vertically lower than) the central axis A1. In other words, both the upstream end portion of the contacting part N and the downstream end portion of the contacting part N in the rotating direction X are positioned lower than the central axis A1.

Accordingly, gravity can reliably suppress the amount of foreign matter on the sheet S that becomes deposited on the circumferential surface of the drum body **57** constituting the photosensitive drum **20**.

(4) As shown in FIG. **2**, the printer **1** includes the scorotron charger **22**, which is configured to charge the circumferential surface of the drum body **57** constituting the photosensitive drum **20**. The scorotron charger **22** is disposed above (vertically higher than) the central axis A1 and confronts but is separated from the drum body **57**.

Further, the developing roller **34** and transfer roller **21** are arranged such that their respective central axes A4 and A2 are positioned lower than the central axis A1 of the photosensitive drum **20**, and their respective rubber roller **66** and roller body **60** are in contact with the drum body **57** of the photosensitive drum **20**.

Accordingly, the developing roller **34** and transfer roller **21** both support the photosensitive drum **20** from below.

Thus, this structure maintains a uniform positional relationship between the scorotron charger **22** disposed vertically above the central axis A1 and the drum body **57** so that the scorotron charger **22** can reliably charge the circumferential surface of the drum body **57**.

Sometimes extraneous matter such as toner (residual toner) remains on the circumferential surface of the drum body **57** after the image-transferring operation.

This residual toner is charged to approximately the same potential as the circumferential surface of the drum body **57** when rotated to confront the scorotron charger **22**. Therefore, the residual toner is reliably recovered on the rubber roller **66** when confronting and contacting the same, due to its potential difference with the developing roller **34**.

Accordingly, this configuration can reliably recover extraneous matter deposited on the circumferential surface of the drum body **57**, and particularly residual toner.

Hence, the printer **1** can reliably charge the circumferential surface of the drum body **57** and can reliably recover extraneous matter, and particularly residual toner, deposited on the circumferential surface of the drum body **57**.

(5) As shown in FIG. **2**, the paper discharge opening **55** is formed in the drum-accommodating section **51** between the scorotron charger **22** and transfer roller **21** in the circumferential direction of the drum body **57**, and the drum opening **53** is arranged on the front portion of the drum-accommodating section **51**.

In an image-forming operation, the laser beam L emitted from the scanning unit **16** passes through the drum opening **53** and between the scorotron charger **22** and the developing roller **34** with respect to the circumferential direction of the drum body **57** before exposing the circumferential surface of the drum body **57**, as shown in FIG. **1**.

In other words, the scorotron charger **22**, transfer roller **21**, and developing roller **34** can be efficiently arranged along the circumferential direction of the drum body **57** to ensure an optimal layout for a cleanerless system.

Hence, the printer **1** can be made smaller while minimizing scratching to the circumferential surface of the drum body **57** and reliably recovering extraneous matter deposited on the circumferential surface of the drum body **57**.

(6) As shown in FIG. **2**, the supply roller **33** is disposed on the opposite side of the developing roller **34** from the photosensitive drum **20**, and the sponge roller **64** of the supply roller **33** confronts and contacts the rubber roller **66** of the developing roller **34**. Accordingly, the supply roller **33** supports the developing roller **34** on the side opposite the photosensitive drum **20**.

Hence, this arrangement minimizes warping in the developing roller **34** in order to maintain a constant positional relationship between the developing roller **34** and photosensitive drum **20**, thereby ensuring stable contact between the rubber roller **66** and drum body **57**.

As a result, the developing roller **34** can provide a stable supply of toner to the electrostatic latent images and can even more reliably recover extraneous matter that has become deposited on the circumferential surface of the drum body **57**.

(7) As shown in FIG. **2**, the printer **1** is provided with the lower film **36** disposed beneath the drum body **57** of the photosensitive drum **20** in a position that overlaps the central axis A1 when projected vertically.

Accordingly, any extraneous matter (paper dust or other foreign matter, for example) that falls off the circumferential surface of the drum body **57** due to gravity will accumulate on the top surface of the lower film **36**.

Since the front end of the lower film **36** is in contact with the circumferential surface of the rubber roller **66** constituting

the developing roller **34**, extraneous matter accumulated on the lower film **36** is recovered on the circumferential surface of the rubber roller **66**.

A particular feature of the lower film **36** is that its rear end portion is arranged higher than its front edge that contacts the circumferential surface of the rubber roller **66**. Therefore, extraneous matter accumulating on the top surface of the lower film **36** migrates forward along the top surface of the lower film **36** until arriving at the circumferential surface of the rubber roller **66**. The extraneous matter that arrives at the circumferential surface of the rubber roller **66** is retained on that surface and reliably recovered in the developing-cartridge frame **25** as the developing roller **34** is driven to rotate.

Hence, the lower film **36** and developing roller **34** reduce the occurrence of extraneous matter contaminating the region around the photosensitive drum **20**, even when extraneous matter falls off the circumferential surface of the drum body **57** constituting the photosensitive drum **20** due to gravity.

5. Modifications

While the present invention has been described in detail with reference to the embodiments thereof, it would be apparent to those skilled in the art that various changes and modifications may be made therein without departing from the spirit of the invention.

In the preferred embodiment described above, the cleaning operation is implemented during the image-forming operation.

However, the cleaning operation can also be implemented alone and separate from the image-forming operation.

When the cleaning operation is executed, a developing bias is not applied to the developing roller **34**. Hence, when the extraneous matter is residual toner, the potential difference between the residual toner charged by the scorotron charger **22** and the developing roller **34** will be even greater than in the preferred embodiment described above.

Thus, residual toner deposited on the circumferential surface of the drum body **57** will be even more reliably retained on the circumferential surface of the rubber roller **66** and can therefore be more reliably recovered or reused.

This variation can obtain the same operational advantages described above in the preferred embodiment.

In addition to the monochrome printer described above, the image-forming device of the present invention may be configured as a color printer.

When configured as a color printer, the image-forming device may be configured as a direct tandem color printer provided with a plurality of photosensitive bodies, and a recording medium conveying member; or as an intermediate transfer tandem color printer provided with a plurality of photosensitive bodies, an intermediate transfer body, and a transfer member.

In addition to the separable process cartridge **15** that allows the drum cartridge **18** and developing cartridge **19** to be separated from each other, as described above, the process cartridge **15** may be an integrated unit in which the drum cartridge **18** and developing cartridge **19** are integrally provided.

It is also possible to provide the photosensitive drum **20** in the main casing **2**, while enabling only the developing cartridge **19** to be mounted in and removed from the main casing **2**.

The developing cartridge **19** may also be configured in a frame having the developing roller **34**, and a toner cartridge for accommodating toner may be detachably mounted in the frame.

Instead of the agitator **29** described above, an auger screw, a conveying belt, or another member may be used as the conveying member.

Instead of the scorotron charger **22** described above, a non-contact-type charger such as a corotron-type charger and a charger provided with a sawtooth discharge member, or a contact-type charger such as a charging roller may be used as the charger.

The image-forming device of the present invention may also be configured as a multifunction peripheral that is equipped with an image-reading unit and the like.

These variations can also obtain the same operational advantages described above in the preferred embodiment.

Note that the preferred embodiment and variations described above may also be suitably combined.

What is claimed is:

1. An image forming apparatus comprising:

a photosensitive drum configured to rotate about a first axis and having a peripheral surface;

a developing roller configured to contact the photosensitive drum and configured to supply developer to the photosensitive drum by rotating about a second axis positioned lower than the first axis in a vertical direction to form a visible image on the peripheral surface, extraneous matter on the peripheral surface being recovered only by the developing roller; and

a film member overlapping the first axis when projected in the vertical direction and having a portion contacting a circumferential surface of the developing roller.

2. The image forming apparatus according to claim **1**, further comprising a transfer roller configured to contact the photosensitive drum and configured to rotate about a third axis positioned lower than the first axis in the vertical direction, the transfer roller configured to transfer the visible image from the peripheral surface to a recording medium, only the developing roller and the transfer roller being in contact with the photosensitive drum.

3. The image forming apparatus according to claim **2**, wherein the photosensitive drum and the transfer roller define a contact portion therebetween, the photosensitive drum being rotatable in a rotating direction such that the recording medium passes through the contact portion; and

wherein the contact portion has an upstream end portion in the rotating direction positioned lower than the first axis in the vertical direction.

4. The image forming apparatus according to claim **3**, wherein the contact portion in its entirety is positioned lower than the first axis in the vertical direction.

5. The image forming apparatus according to claim **2**, further comprising a charger configured to charge the peripheral surface and positioned higher than the first axis in the vertical direction to confront but remain separated from the photosensitive drum.

6. The image forming apparatus according to claim **5**, wherein the photosensitive drum and the transfer roller define a contact portion therebetween, the photosensitive drum being rotatable in a rotating direction such that the recording medium passes through the contact portion;

wherein the image forming apparatus further comprises an exposing device configured to emit a laser beam to the photosensitive drum to form an electrostatic latent image on the peripheral surface;

wherein the recording medium that has passed through the contact portion is discharged between the charger and the transfer roller in a peripheral direction of the photosensitive drum; and

wherein the laser beam passes between the charger and the developing roller in the peripheral direction of the photosensitive drum.

7. The image forming apparatus according to claim **1**, further comprising a supply roller configured to supply developer to the developing roller, the supply roller being positioned opposite to the photosensitive drum with respect to the developing roller.

8. An image forming apparatus comprising:

a photosensitive drum configured to rotate about a first axis and having a peripheral surface;

a developing roller configured to contact the photosensitive drum and configured to rotate about a second axis positioned lower than the first axis in a vertical direction; and

a transfer roller configured to contact the photosensitive drum and configured to rotate about a third axis, the transfer roller being positioned higher than the second axis in the vertical direction, only the developing roller and the transfer roller being in contact with peripheral surface.

9. The image forming apparatus according to claim **8**, wherein the third axis is positioned lower than the first axis in the vertical direction.

10. The image forming apparatus according to claim **8**,

wherein the third axis is positioned lower than the first axis in the vertical direction; and

wherein the transfer roller is configured to transfer a visible image from the peripheral surface to a recording medium.

11. The image forming apparatus according to claim **8**, further comprising a charger configured to charge the peripheral surface and positioned higher than the first axis in the vertical direction to confront but remain separated from the photosensitive drum.

12. The image forming apparatus according to claim **11**, wherein the photosensitive drum and the transfer roller define a contact portion therebetween, the photosensitive drum being rotatable in a rotating direction such that a recording medium passes through the contact portion;

wherein the image forming apparatus further comprises an exposing device configured to emit a laser beam to the photosensitive drum to form an electrostatic latent image on the peripheral surface;

wherein the recording medium that has passed through the contact portion is discharged between the charger and the transfer roller in a peripheral direction of the photosensitive drum; and

wherein the laser beam passes between the charger and the developing roller in the peripheral direction of the photosensitive drum.

13. The image forming apparatus according to claim **8**, further comprising a film member overlapping the first axis when projected in the vertical direction and having a portion contacting a circumferential surface of the developing roller.

* * * * *